

## **High-Fidelity Site-Specific Radar Data Set**

### **DATA FILE DESCRIPTION**

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# High-Fidelity Site-Specific Radar Data Set

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## 1.0 Introduction

This document contains a brief description of the site-specific radar data set contained on this CDROM. This data set contains many real-world effects including heterogeneous terrain, sub-space leakage, array errors, and significant ground traffic. The basis for the phenomenology modeling is the Splatter, Clutter, and Target Signal (SCATS) model<sup>1,2,3</sup> which provides site-specific modeling of propagation and scatter. The next several sections provide a description of the variables in the data files and an example of processing the data.

## 2.0 Simulation Parameters

Key simulation parameters are shown in Table 1. The simulated system nominally follows the parameters of the Multi-Channel Airborne Radar Measurement (MCARM) system.<sup>4</sup> The data file contains a number of simulation parameters, many of which are described in Section 4.0. Note that throughout, all azimuths are given in degrees measured clockwise from true north and all elevations are measured from the local horizon.

parameter	variable name (units)	value
carrier frequency	TxFrequency (Hz)	1240 MHz
bandwidth	BW (Hz)	10 MHz
receive array parameters	RxArray	MATLAB structure
transmit array parameters	TxArray	MATLAB structure
number of pulses	NumPulse	32
minimum range (one way)	rng_min (m)	35,000
maximum range (one way)	rng_max (m)	50,000
range bin range (two way)	rbins (m)	70,000-100,000

**Table 1.** Selected simulation parameters. The MATLAB structures are described in Table 2.

1. P. M. Techau and D. E. Barrick, "Radar phenomenology modeling and system analysis using the Splatter, Clutter, and Target Signal (SCATS) model," ISL Technical Note ISL-TN-97-001, Vienna, VA, October, 1997.
2. J. E. Don Carlos, K. M. Murphy, and P. M. Techau, "An improved clutter, splatter and target signal model," ISL Technical Note ISL-TN-91-003, Vienna, VA, May, 1991.
3. J. E. Don Carlos, "Clutter, splatter, and target radar signal model," ISL Technical Note ISL-TN-89-003, Vienna, VA, November, 1989.
4. D. K. Fenner and W. F. Hoover, "Test results of a space-time adaptive processing system for airborne early warning radar," *Proceedings of the 1996 IEEE National Radar Conference*, Ann Arbor, MI, 13-15, May 1996, pp. 88-93.

parameter	variable name (units)	value
pulse repetition frequency	PRF (Hz)	1984 Hz
peak power	N/A	15 kW
duty factor	N/A	10%
noise figure	N/A	5 dB
system losses	N/A	9 dB
front-to-back ratio (two way)	fb_ratio (dB)	25 dB
platform azimuth heading	TxAzimuth/RxAzimuth (deg)	270
platform height above local terrain	TxHeight/RxHeight (m)	3000
platform speed	TxSpeed/RxSpeed (m/s)	100

**Table 1.** Selected simulation parameters. The MATLAB structures are described in Table 2.

The platform height above sea level can be found from the combination of TxHeight or RxHeight and TxTerrainElevation or RxTerrainElevation and is 5088 m. The transmit and receive arrays are Specified in the MATLAB structures TxArray and RxArray. These structures are identical and described in Table 2.

parameter	structure variable (units)	value
horizontal element spacing	dh (m)	0.1092
vertical element spacing	dv (m)	0.1407
number of horizontal elements	Nh	11
number of vertical elements	Nv	8
number of array channels	NumChannels	11
number of columns in each subarray	Hplane	NumChannels $\times$ 1 array
number of rows in each subarray	Vplane	NumChannels $\times$ 1 array
array boresight azimuth	boresight_az (deg)	177
array boresight elevation	boresight_el (deg)	-5
azimuth pre-steer	pre_steer_az (deg)	195
elevation pre-steer	pre_steer_el (deg)	-5
array horizontal axis	a_x	3 $\times$ 1 array
array vertical axis	a_y	3 $\times$ 1 array
channel indices	idx	NumChannels $\times$ 2 array
super element (subarray) phase centers	sepos (m)	NumChannels $\times$ 3 array

**Table 2.** Description of array MATLAB variable structure. This structure is used to describe both the transmit and receive arrays (TxArray and RxArray).

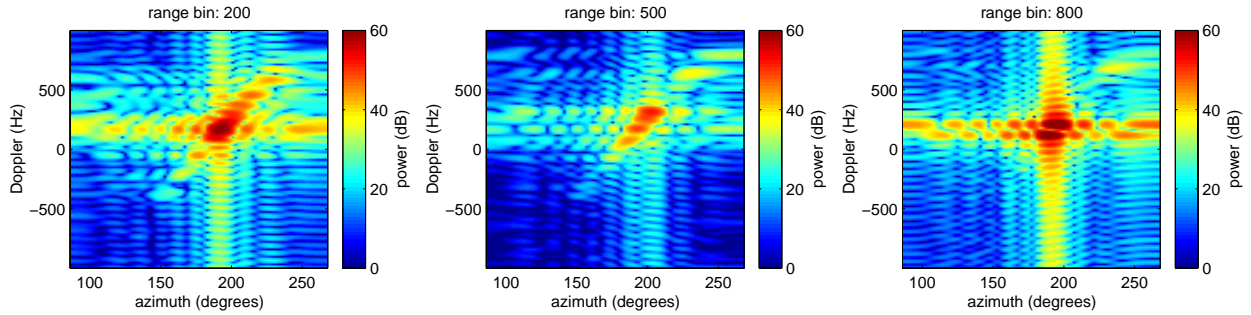
‘Perfect’ pulse compression is assumed, that is there are no range sidelobes, and the sample rate equals the bandwidth. Other variables which may appear in the clutter data file are those generated by SCATS and define the simulation scenario. Section 4.0 shows these variables and provides a description of them. The transmit element is a simple dipole, thus it has a very broad

beam. The columns in `Rxarray.sepos` (or `TxArray.sepos`) are the  $x$ ,  $y$ , and  $z$  coordinates of each array position using a coordinate system in which the local  $x$  points north,  $y$  points west, and  $z$  points up. This coordinate system is used in order to obtain a right-handed coordinate system with the  $x$  axis as the reference for the azimuth angle. Note that within this coordinate system, azimuth and elevation relate to the usual spherical earth coordinate angles<sup>1</sup> (measured in degrees) by:

$$\begin{aligned}\phi &= 360 - \text{azimuth} \\ \theta &= 90 - \text{elevation}\end{aligned}$$

### 3.0 Clutter Simulation Data

The simulated clutter data is in the file `lband_set1.mat`. The radar data cube is in the variable `xc`. This variable has dimensions `NumChannels × NumPulse × length(rbins)`. For the parameters used in the simulation the dimensions are  $11 \times 32 \times 1000$ . The angle-Doppler power spectral densities (PSDs) of data from selected range bins are shown in Figure 1.



**Figure 1.** Angle-doppler PSDs of selected range bins for the data set.

These spectra were formed by using the included MATLAB scripts `compute_psd.m` and `stvect.m`. Simply run the script `compute_psd.m` with the data file and both m-files in the same directory. The script can readily be modified to plot the desired range bin number and provides an example of space-time beamforming of the data.

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1. e.g., W. H. Hayt, *Engineering Electromagnetics*, McGraw-Hill, New York, 1981, p. 21 ff.

## 4.0 Description of SCATS Model Variables

This table provides complete documentation of MATLAB variables generated by ISL's SCATS model. Not all of these variables appear in the data file (in some cases, the variables would be appropriate only in a bistatic scatter scenario). However, this table is provided as a reference for users of the data file in determining the various detailed parameters of the simulation.

MATLAB Variable	Description
AzfromRxtToTx	azimuth AoA (angle of arrival) at the receive end of the direct path in degrees
AzfromTtxToRx	azimuth AoA (angle of arrival) at the transmit end of the direct path in degrees
CelFileDate	string containing the date of the cell file, day/month/year.
CelFileName	string containing the cell file name.
CelFileTime	string containing the cell file time.
CelleW	dimension of cell (scattering patch) East to West in meters.
CellHeight	Height in meters above local terrain assumed for the cell end of the half path for propagation calculations meters.
CellNS	dimension of cell (scattering patch) North to South in meters.
ElfromRxtToTx	elevation AoA (angle of arrival) at the receive end of the direct path in degrees.
ElfromTtxToRx	elevation AoA (angle of arrival) at the transmit end of the direct path in degrees.
Er	real and imagery part of the permittivity in Farads/meter ( $\epsilon_r - j\sigma/\omega\epsilon_0$ ) used in the two-scale scattering models.
GainFileDate	string containing the date of the gain file, day/month/year.
GainFileName	string containing the gain file name.
GainFileTime	string containing the gain file time.
GainHH	HH polarization component of power without the gains of the transmitter and receiver.
GainHV	HV polarization component of power without the gains of the transmitter and receiver.
GainVH	VH polarization component of power without the gains of the transmitter and receiver.
GainVV	VV polarization component of power without the gains of the GainVV transmitter and receiver.
InFileDate	Infile date, day/month/year.
InFileName	string containing the infile name.
InFileTime	string containing the infile time.
LScorrLength	large scale correlation length for the Gaussian height spectrum scattering model.
LsrmsHeight	large scale rms height for the Gaussian height spectrum scattering model.
LengthEW	length of the area of calculation from East to West in meters.
LengthNS	length of the area of calculation from North to South in meters
MultipathMode	string indicating whether or not the multipath is removed within 1 km of the cell end of the half-path.
PathDoppler	total path doppler of each cell.
PathPower	power received from each cell.
PathRange	total path length for each cell.
PhillipsCoef	coefficient for the Phillips height spectrum scattering model.
RCS	radar cross section when using the target model.

**Table 3.** SCATS Variables

<b>MATLAB Variable</b>	<b>Description</b>
RMSslope	RMS slope used in the Phillips height spectrum scattering model.
ReferenceLatitude	displacement angle from the southmost latitude of the area of calculation in degrees North.
RxAntAzimuth	receive antenna's axis azimuth in degrees
RxAntElevation	receive antenna's axis elevation in degrees.
RxAzfromCell	azimuth AoA at the cell end of the receive halfpath in degrees.
RxAzimuth	azimuth of the velocity of the receiver in degrees.
RxAztoCell	azimuth AoA at the receive end of the receive halfpath in degrees.
RxElevation	elevation of the velocity of the receiver in degrees.
RxEIfromCell	elevation AoA at the cell end of the receive halfpath in degrees.
RxEItoCell	elevation AoA at the receive end of the receive halfpath in degrees.
RxExcessLossH	propagation factor for horizontal polarization along the receive halfpath in dB.
RxExcessLossV	propagation factor for vertical polarization along the receive halfpath in dB.
RxFileDate	string containing the receive file date in day/month/year.
RxFileName	string containing the name of the receive file.
RxFileTime	string containing the time of the receive file.
RxHeight	height of the receiver above local terrain in meters.
RxLatitude	latitude of the receiver in degrees North.
RxLongitude	longitude of the receiver in degrees West.
RxPropagationMode	<p>string containing the propagation mode of the receive halfpath.</p> <p>Originally in binary format, the propagation is converted into decimal format for MATLAB. If the propagation equals 3, long path and GOPT Multipath are the propagation modes.</p> <p>Binary Format Bit #</p> <p>0 long path</p> <p>1 GEOS Multipath</p> <p>2 GOPT Mutipath (geometric optics)</p> <p>3 Knife Edge Diffraction</p> <p>4 Spherical Earth Diffraction</p>
RxRange	range from the receiver to each cell in meters.
RxSpeed	speed of the receiver in meters/second.
RxTerrainElevation	(local) terrain elevation (above sea level) at the receiver in meters.
SScorrLength	small scale correlation length for the Gaussian height spectrum scattering model.
SSrmsHeight	small scale rms height for the Gaussian height spectrum scattering model
ScatRxAntType	string containing the type of antenna (Isotropic, Dipole) used at the receiver for the two-scale scattering models.
ScatTxAntType	string containing the type of antenna (Isotropic, Dipole) used at the transmitter for the two-scale scattering models.
ScatteringCurve	string containing the type of scattering curve used.

**Table 3. SCATS Variables**

MATLAB Variable	Description
SigmaFloor	minimum value of scattering curve for the monostatic equivalent scattering model or the value used for constant scattering coefficient.
SouthmostLatitude	south most latitude of the area of calculation in degrees.
TRxExcessLossH	propagation factor for horizontal polarization along the direct path in dB.
TRxExcessLossV	propagation factor for vertical polarization along the direct path in dB.
TRxPropagationMode	<p>a number containing the propagation mode of the direct path file.</p> <p>Originally in binary format, the propagation is converted into decimal format for MATLAB. If the propagation equals 7, long path, GEOS, and GOPT Multipath are the propagation modes.</p> <p>Binary Format Bit #</p> <p>0 long path</p> <p>1 GEOS Multipath</p> <p>2 GOPT Mutipath (geometric optics)</p> <p>3 Knife Edge Diffraction</p> <p>4 Spherical Earth Diffraction</p>
TRxRange	range from the transmitter to the receiver in meters.
TerrainHeight	terrain height at each cell in meters.
TerrainUnitX	x component of the terrain normal vector (normalized) in meters
TerrainUnitY	y component of the terrain normal vector (normalized) in meters.
TerrainUnitZ	z component of the terrain normal vector (normalized) in meters.
TxAntAzimuth	transmit antenna's axis azimuth in degrees.
TxAntElevation	transmit antenna's axis elevation in degrees.
TxAzfromCell	azimuth AoA at the cell end of the transmit halfpath in degrees.
TxAzimuth	azimuth of the velocity of the transmitter in degrees.
TxAztoCell	azimuth AoA at the transmit end of the receive halfpath in degrees.
TxElevation	elevation of the velocity of the transmitter in degrees.
TxElfromCell	elevation AoA at the cell end of the transmit halfpath in degrees.
TxEltoCell	elevation AoA at the transmit end of the transmit halfpath in degrees.
TxExcessLossH	propagation factor for horizontal polarization along the transmit halfpath in dB.
TxExcessLossV	propagation factor for vertical polarization along the transmit halfpath in dB.
TxFileDate	string containing the transmit file date in day/month/year.
TxFileName	string containing the name of the transmit file.
TxFileTime	string containing the time of the transmit file.
TxFrequency	frequency of the transmitter in Hertz.
TxHeight	transmitter height above local terrain in meters.
TxLatitude	latitude of the transmitter in degrees North.
TxLongitude	longitude of the transmitter in degrees West.

**Table 3.** SCATS Variables

MATLAB Variable	Description
TxPropagationMode	<p>a number containing the propagation mode of the transmit halfpah.</p> <p>Originally in binary format, the propagation is converted into decimal format for MATLAB. If the propagation equals 21, long path, GOPT Multipath, and Spherical Earth Diffraction are the propagation modes.</p> <p>Binary Format Bit #</p> <p>0 long path</p> <p>1 GEOS Multipath</p> <p>2 GOPT Mutipath (geometric optics)</p> <p>3 Knife Edge Diffraction</p> <p>4 Spherical Earth Diffraction</p>
TxRange	range of from the transmitter to each cell in meters.
TxSignalPower	transmitter power in Watts.
TxSpeed	speed of the transmitter in meters/second.
TxTerrainElevation	(local) terrain elevation (above sea level) at the transmitter in meters.
Ur	permeability in Henrys/meter used in the two-scale scattering model.
WestmostLongitude	West most longitude of the area of calculation in degrees.

**Table 3.** SCATS Variables